Lab 2: Building and Matching a Dipole Antenna for use with the wireless LAN

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Equipment:

- Agilent 8510C Microwave Vector Network Analyzer
- TRL Calibration Kit

Procedure:

1. Use sandpaper to remove the outer coating from some copper wire greater than 3 cm in length.
2. Cut the wire to approximately 3.5 cm, bend the end so that it can be soldered on the micro-strip board, and use the soldering iron to place the monopole wire on the micro-strip. Since the ground plane is large, the monopole will actually act as a dipole antenna.
3. For this lab, you will use the circuit board holder. Later you could optionally mount the SMA connector to the end of the micro-strip line on the end of the board.
    a. Solder the center conductor from the SMA connector to the end of the micro-strip line.
    b. Solder a piece of wire to the outer part of the connector and solder the other end of the wire to the ground plane side of the micro-strip board.
4. Calibrate the Network Analyzer
    a. If you are using the circuit board holder, perform the TRL calibration as described in the network analyzer handout from Lab 1. The frequency range for this calibration should be from 2-3 GHz. Check the calibration to make sure that it is accurate using the THRU and REFLECT standards.
    b. If you are using SMA connectors, perform either the S11 or S22 one-port calibration as defined in the handout from Lab 1. This is very similar to the Full 2-port calibration, except that it should be much faster. The frequency range for this calibration should be from 2-3 GHz. Check the calibration to make sure that it is accurate.
5. Attach the antenna to the network analyzer (via the circuit board holder or SMA connector) and look at the values for S11 and the input impedance. Since the antenna is still longer than 3 cm, it should have resonance below 2.5 GHz. Resonance is when the real part of the impedance becomes very large and the imaginary part crosses zero (generally rising sharply to a large positive value, then falling sharply to a large negative value). At resonance, the S11 value should be small, but this will depend on the value of the real part at resonance. Remember you are connected to a 50 ohm network analyzer. Shorten the antenna (with wire cutters) so that it has a length approximately equal to a quarter wavelength at 2.5 GHz. Remember the equation for wavelength is $\lambda = c/f$. You are measuring the impedance of the antenna PLUS a the length of microstripline between the antenna and the network analyzer calibration location (the center of the THRU on the circuit holder or the end of the cable when not using the holder).
6. The actual length of the micro-strip line on the board is about 4.445 cm (1750 mils). One quarter wavelength on the micro-strip line is 1.88 cm (740.66 mils). The width of the line for a characteristic impedance of 50 ohms is .1789 cm (70.419 mils), which is the width of the milled line. The Smith Chart can be used to find the load impedance of the antenna by rotating the correct number of

wavelengths *toward the load*. Perform this calculation for 2.5 GHz and record the load impedance for the antenna. (An ideal dipole antenna has an impedance of 73 + j 42.5 ohms).

7. Use the Tline software on the PC's to find an open circuit parallel single stub match for the antenna. Record your values for d and L. Assume that you will be using a parallel stub of approximately 50 ohms.
8. Cut a piece of copper tape to the same width as the line on the board with the antenna on it (eyeball it). Use the results from Tline (in wavelengths) and the values given above (for wavelength in cm) to find the actual length in centimeters for the location of the stub and the length of the stub.
9. DON'T tape it down yet! Cut the stub long enough that it can be taped to the microstrip line (overlapping the line as much as possible) and still be longer than the value necessary for L. This will allow for some trimming if necessary (it IS necessary).
10. Experiment with moving the stub (a pencil eraser works great for this) and trimming its length to get an optimal match at 2.5 GHz. This means the imaginary part should be zero, and the real part should be 50 ohms, so the S11 value should be as small as possible.
11. Is the match as good as you expected it to be? How do the length of the stub and its location compare the values that you calculated previously?
12. The frequencies of operation for the wireless LAN are 2.4 and 2.6 GHz. A low value for VSWR is desirable at both of these frequencies. If time allows, use some creativity and slide some pieces of copper tape down the line to see the effects they will have on the VSWR of the circuit. If a particular location looks beneficial, place the tape at the location. You may be able to get a better response by shortening the tape, but do it judiciously since it may also be a detriment to the amount of power that is received by the receiver of the wireless LAN. Since this will be one of the components of the circuit for the final project for this class, make it as good as you can. This will help you save time at the end of the semester when you might have other projects besides this one. You do have the code to the microwave lab, so if necessary, you are encouraged to make modifications outside of the scheduled lab time.
13. Conclusion: explain the results of this lab, what you have learned, and any observations that you may have come to while working on this lab. Include a plot of your impedance, S11, VSWR. Save the data to disk for future use. Carefully save your antenna. Write your names on it. You can leave it in the box in the glass cases in the back of the lab.

CONGRATULATIONS! You now have a matched antenna for your WLAN.